US009438801B2

(12) **United States Patent**
Hwang et al.

(10) **Patent No.: US 9,438,801 B2**
(45) **Date of Patent: Sep. 6, 2016**

(54) **CAMERA MODULE HAVING A MOVING FRAME**

(71) Applicant: **SAMSUNG ELECTRONICS CO., LTD.**, Suwon-si, Gyeonggi-do (KR)

(72) Inventors: **Young-jae Hwang**, Suwon-si (KR); **Kwang-seok Byon**, Yongin-si (KR); **Seung-hwan Lee**, Suwon-si (KR); **Bong-su Jung**, Seoul (KR)

(73) Assignee: **Samsung Electronics Co., Ltd.**, Suwon-si (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 149 days.

(21) Appl. No.: **14/182,544**

(22) Filed: **Feb. 18, 2014**

(65) **Prior Publication Data**

US 2015/0049209 A1 Feb. 19, 2015

(30) **Foreign Application Priority Data**

Aug. 19, 2013 (KR) 10-2013-0098132

(51) **Int. Cl.**

H04N 5/228	(2006.01)
H04N 5/232	(2006.01)
G02B 7/09	(2006.01)
H04N 5/225	(2006.01)

(52) **U.S. Cl.**

CPC ***H04N 5/23287*** (2013.01); ***G02B 7/09*** (2013.01); ***H04N 5/2257*** (2013.01)

(58) **Field of Classification Search**

CPC H04N 5/23287; H04N 5/2254; H04N 5/2257; H04N 5/23248; H04N 5/23264; H04N 5/2253; H04N 5/23258; H04N 5/2328; H04N 5/335; G02B 27/646; G02B 27/642

USPC 348/208.1–208.99

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,818,181	B1	8/2014	Hwang et al.	
2005/0174465	A1	8/2005	Akada	
2005/0185531	A1*	8/2005	Jang	G11B 7/0933 369/44.22
2006/0257129	A1*	11/2006	Shibatani	396/55
2007/0133967	A1*	6/2007	Takahashi et al.	396/55

(Continued)

FOREIGN PATENT DOCUMENTS

JP	2004-163748	A	6/2004
JP	2006-184544	A	7/2006
KR	10-2012-0067653	A	6/2012

OTHER PUBLICATIONS

PCT Search Report and Written Opinion issued for PCT/KR2014/007209 (Nov. 19, 2014).

(Continued)

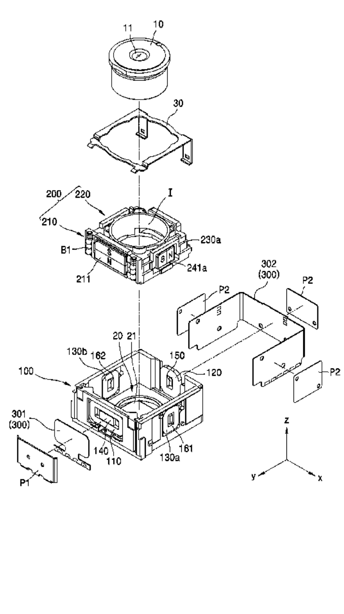
Primary Examiner — Chia-Wei A Chen

(74) *Attorney, Agent, or Firm* — Drinker Biddle & Reath LLP

(57) **ABSTRACT**

A camera module includes a lens barrel including at least one lens group; a moving frame that includes the lens barrel and moves in an optical axis direction and in a first direction and a second direction that are perpendicular to the optical axis direction; a fixed frame that movably supports the moving frame and provides the moving frame with a driving force in the optical axis direction, a driving force in the first direction, and a driving force in the second direction; and a base that fixes the fixed frame and includes an image sensor that is spaced apart from the at least one lens group in the optical axis direction.

27 Claims, 12 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

2010/0091120 A1 4/2010 Nagata et al.
2010/0134902 A1* 6/2010 Naitou 359/696
2011/0096178 A1 4/2011 Ryu et al.
2011/0217029 A1 9/2011 Wu et al.
2011/0236008 A1 9/2011 Kang et al.
2012/0082442 A1 4/2012 Kwon et al.
2012/0105960 A1* 5/2012 Park et al. 359/554
2012/0147258 A1 6/2012 Park
2012/0229926 A1* 9/2012 Wade et al. 359/824
2013/0016427 A1* 1/2013 Sugawara 359/557
2013/0027790 A1* 1/2013 Park et al. 359/824
2013/0162849 A1* 6/2013 Wu H04N 5/225 348/208.4
2013/0170039 A1* 7/2013 Miyoshi 359/554
2013/0177301 A1* 7/2013 Nakayama et al. 396/55
2013/0201559 A1* 8/2013 Minamisawa et al. 359/557
2013/0258172 A1* 10/2013 Seol et al. 348/357
2013/0265394 A1 10/2013 Lim
2015/0207968 A1* 7/2015 Yeo G03B 5/00 348/374
2015/0229843 A1* 8/2015 Shimizu 348/222.1
2015/0370086 A1* 12/2015 Hamada G03B 5/00 359/557

OTHER PUBLICATIONS

European Search Report issued for related application EP 14158883.0, Aug. 17, 2015, 3 pages.

* cited by examiner

FIG. 1

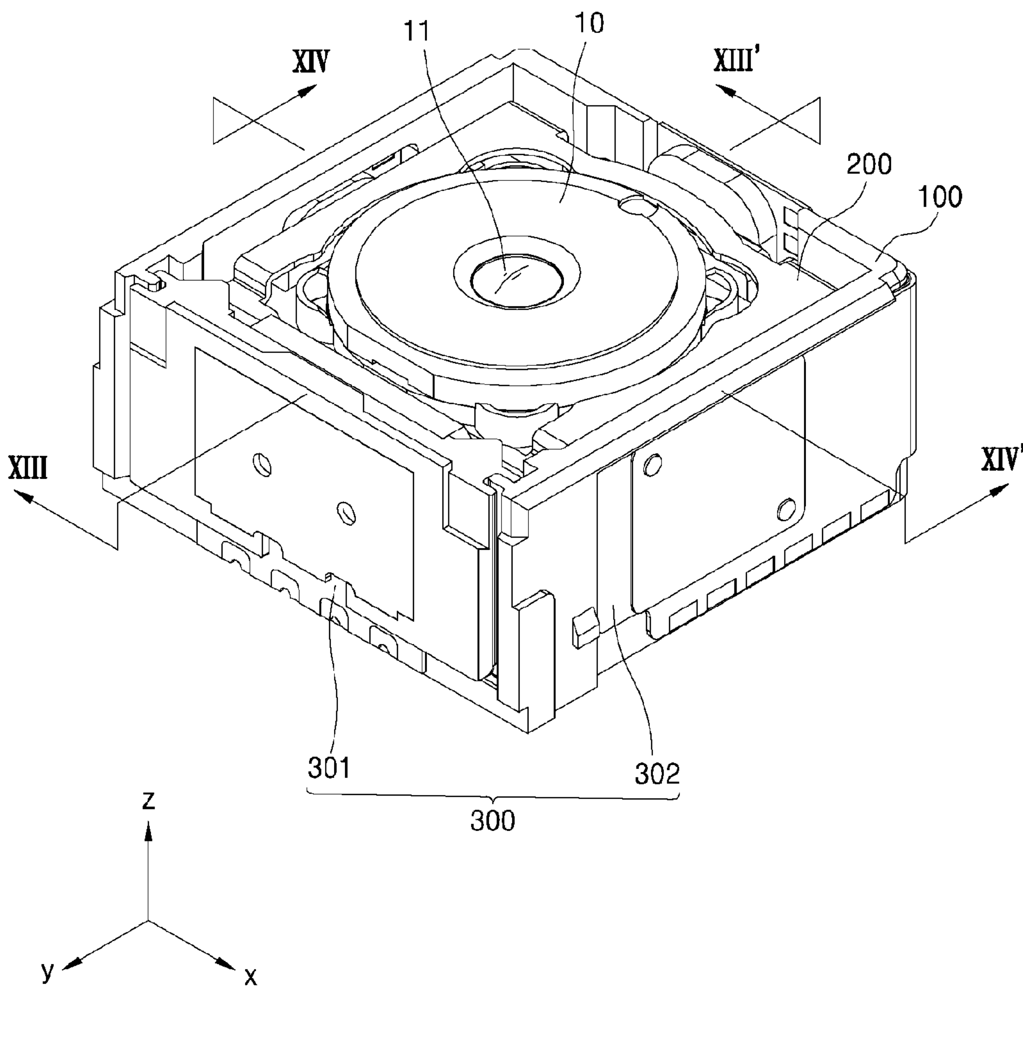


FIG. 2

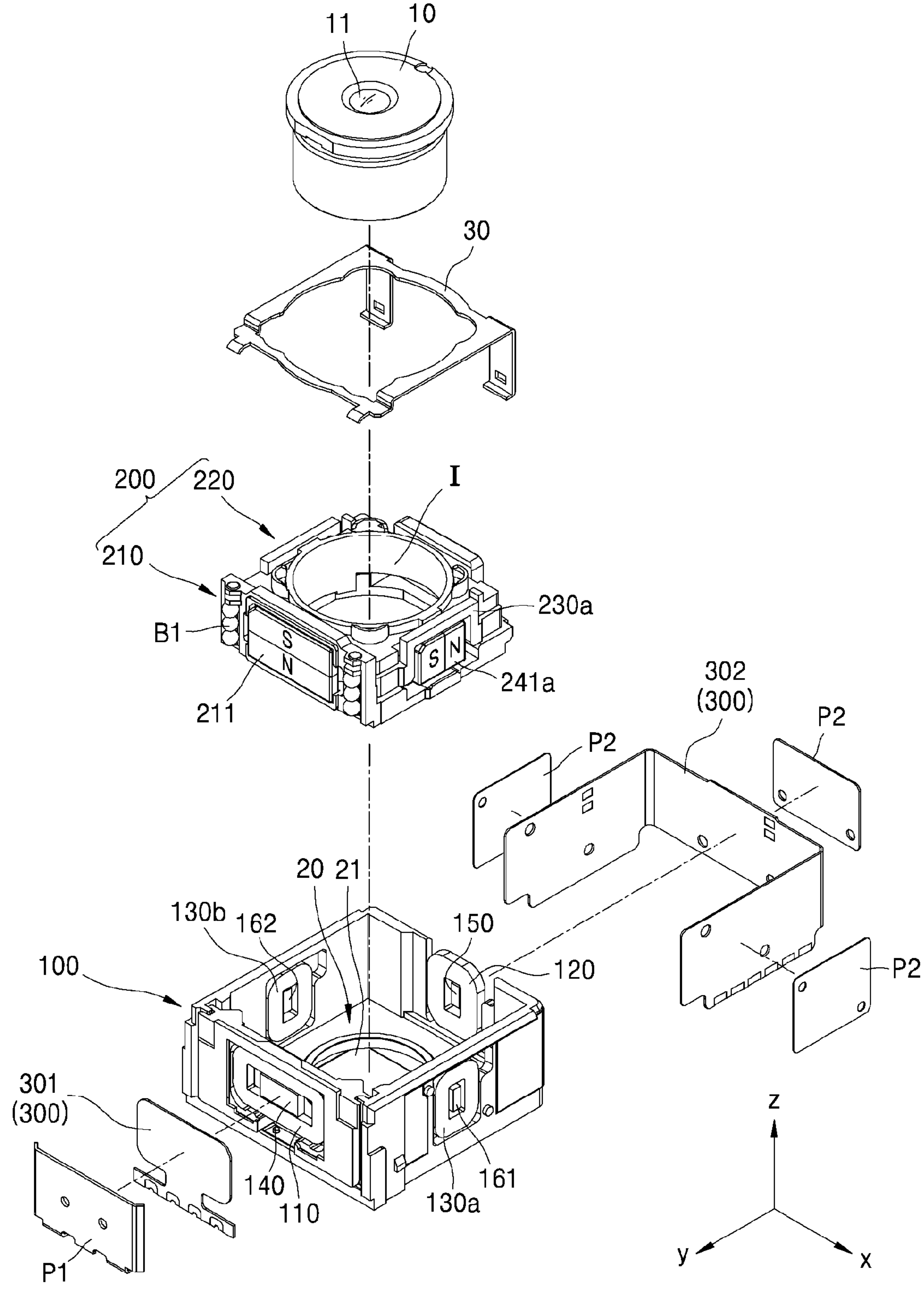

11
10
30
200
220
I
210
B1
230a
S
N
S N
241a
211
302
(300)
P2
P2
P2
20 21
130b
162
150
100
120
301
(300)
140
110
130a
161
P1
z
y
x

FIG. 3

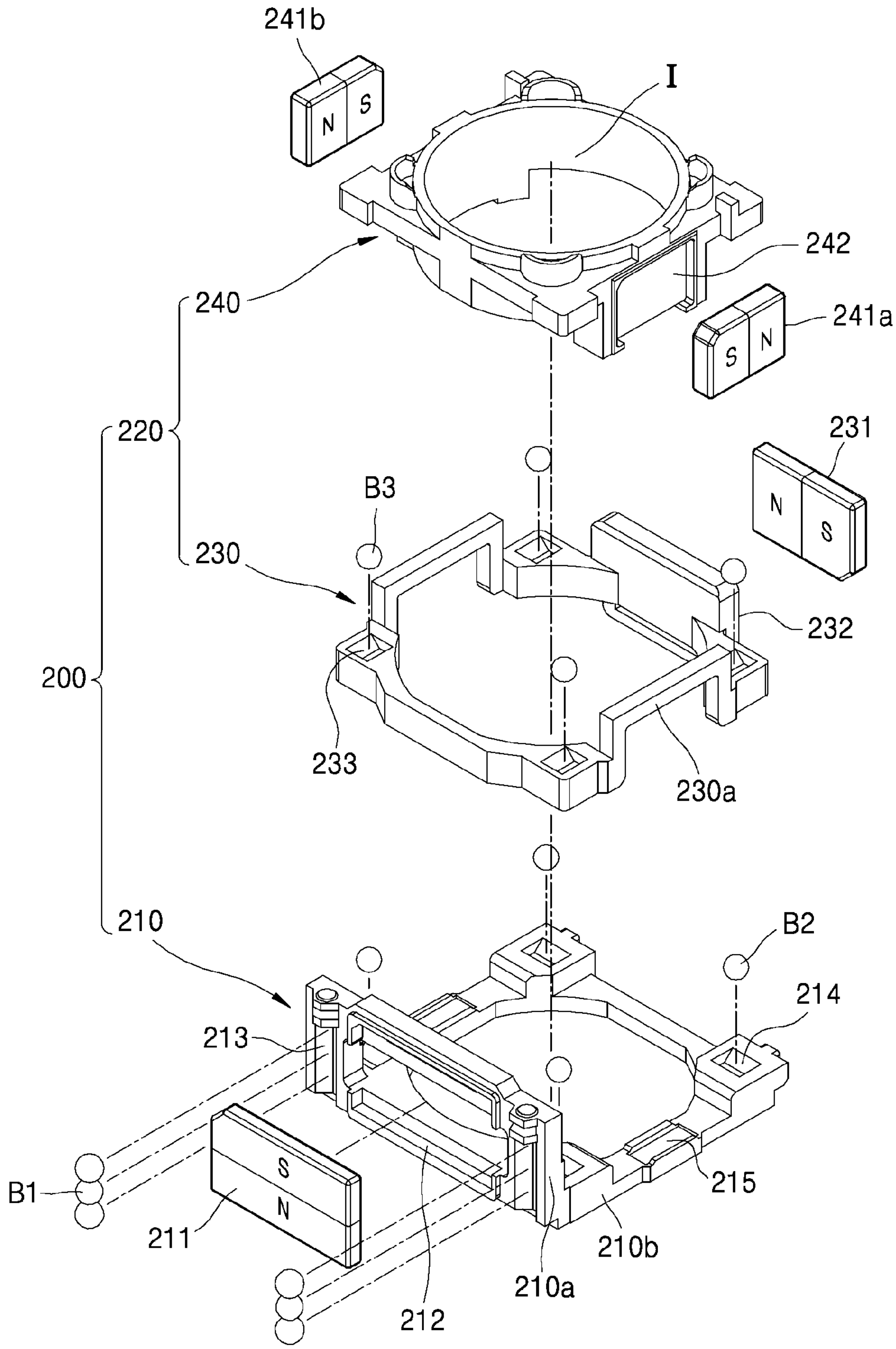

241b
N
S
I
242
240
241a
S
N
220
231
N
S
B3
230
232
200
233
230a
210
B2
214
213
S
N
B1
211
215
210b
210a
212

FIG. 4

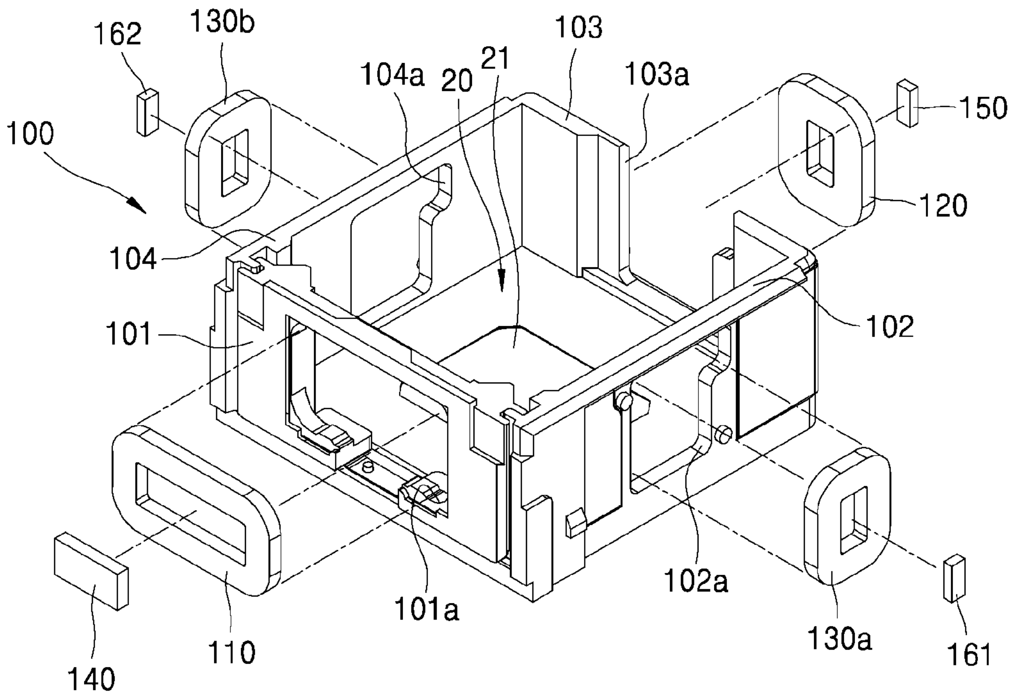

162
130b
103
104a
20
21
103a
150
100
120
104
101
102
101a
102a
140
110
130a
161

FIG. 5

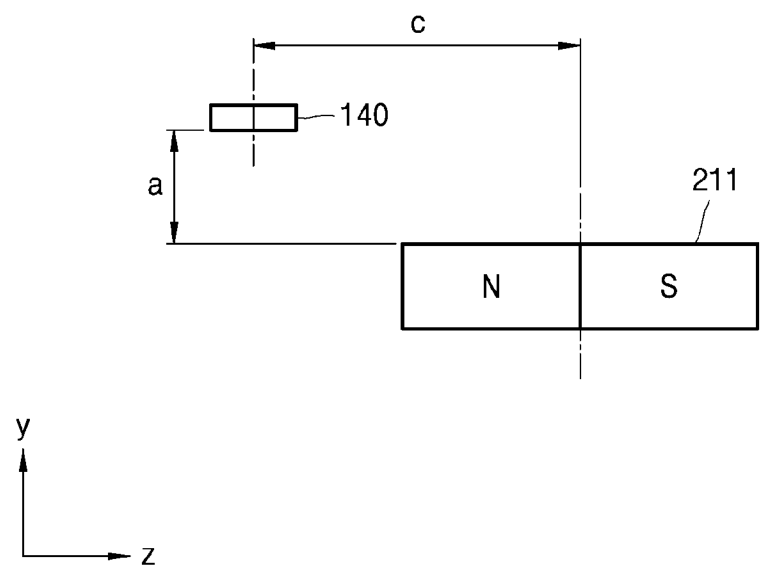


FIG. 6

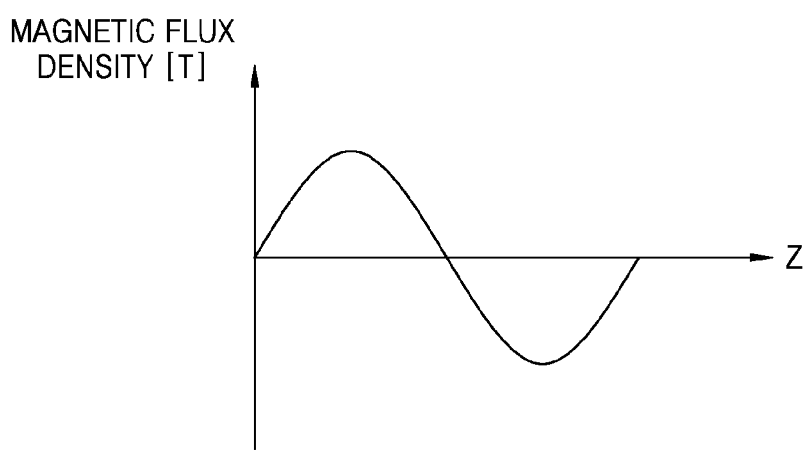


FIG. 7

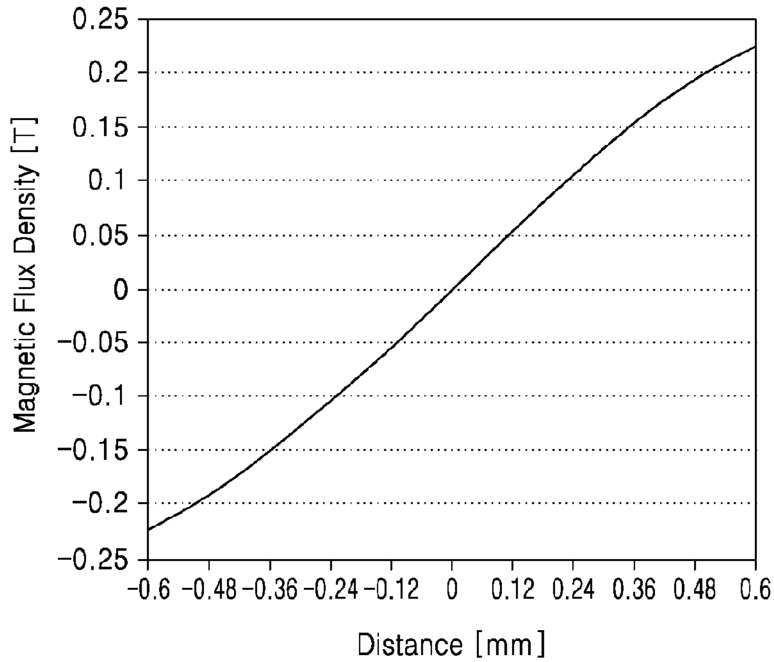

0.25
0.2
0.15
0.1
0.05
0
−0.05
−0.1
−0.15
−0.2
−0.25
Magnetic Flux Density [T]
−0.6 −0.48 −0.36 −0.24 −0.12 0 0.12 0.24 0.36 0.48 0.6
Distance [mm]

FIG. 8

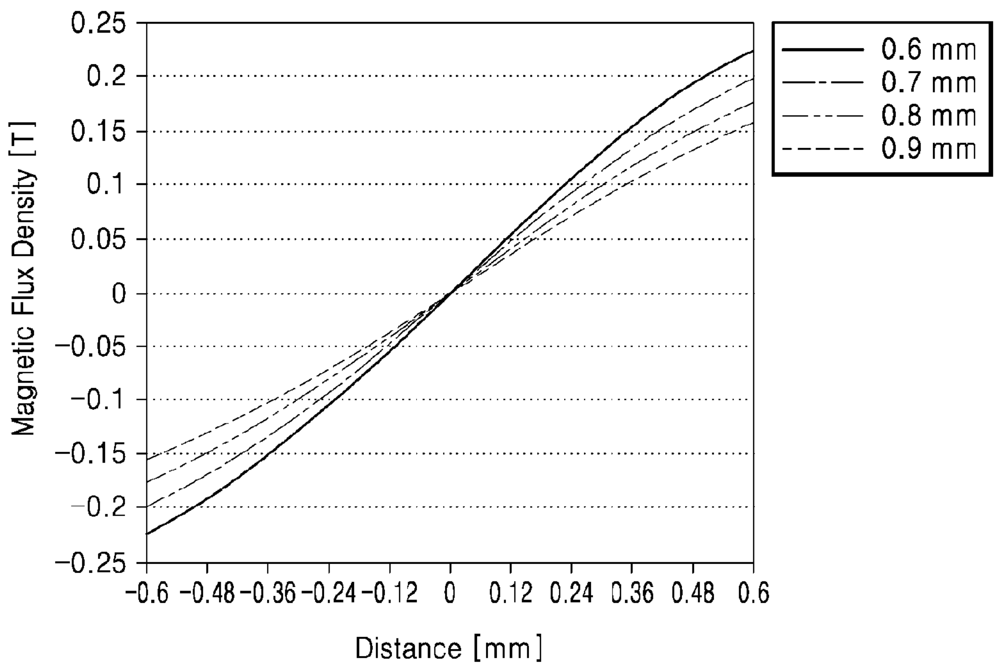

0.25
0.2
0.15
0.1
0.05
0
−0.05
−0.1
−0.15
−0.2
−0.25
Magnetic Flux Density [T]
−0.6 −0.48 −0.36 −0.24 −0.12 0 0.12 0.24 0.36 0.48 0.6
Distance [mm]
0.6 mm
0.7 mm
0.8 mm
0.9 mm

FIG. 9

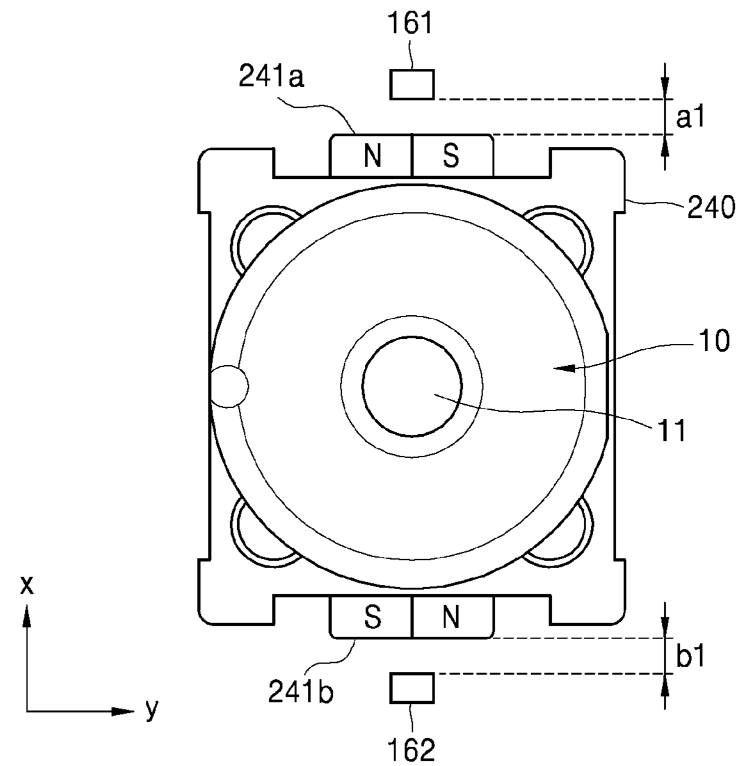


FIG. 10A

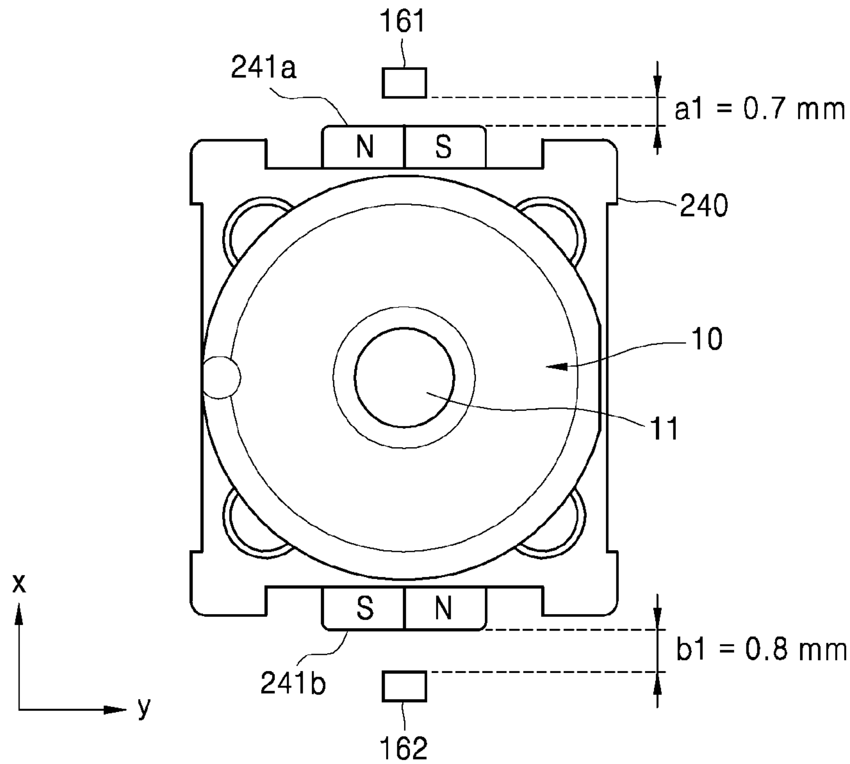


FIG. 10B

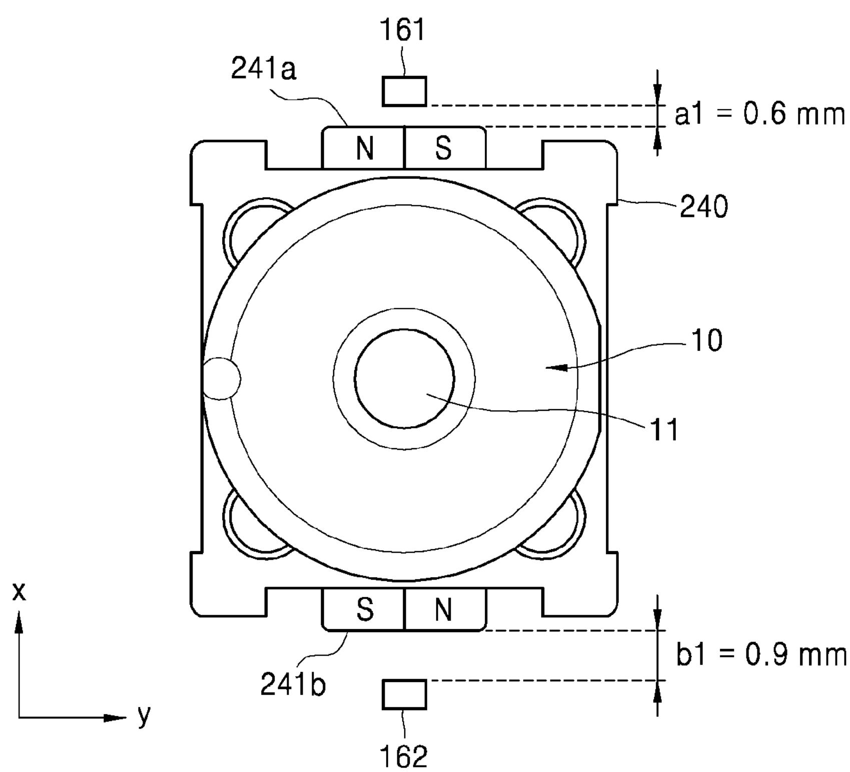


FIG. 11A

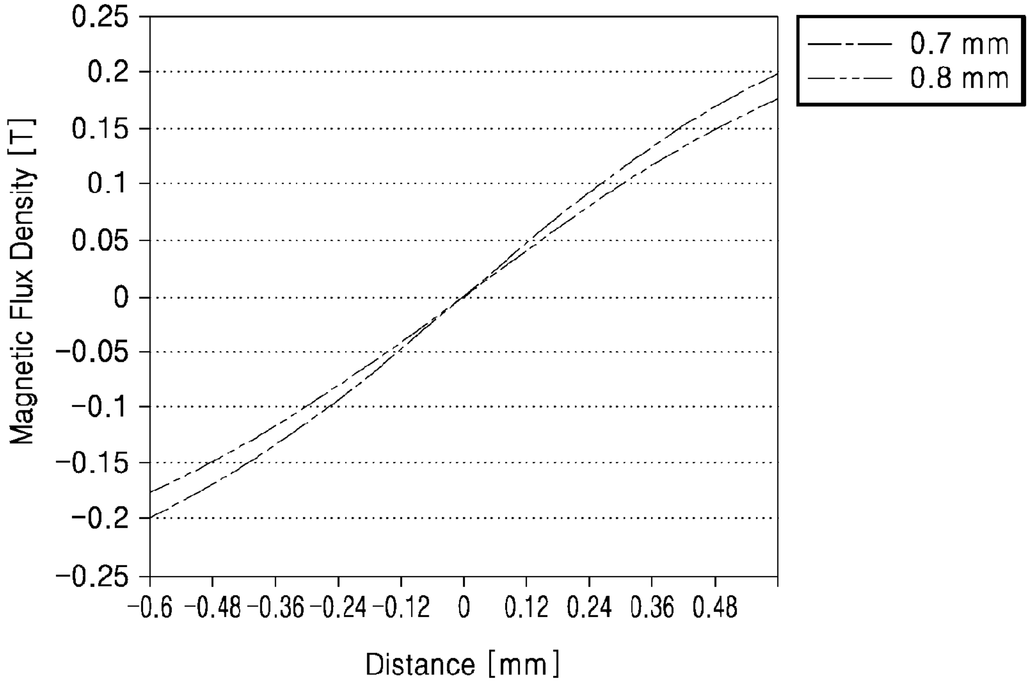


FIG. 11B

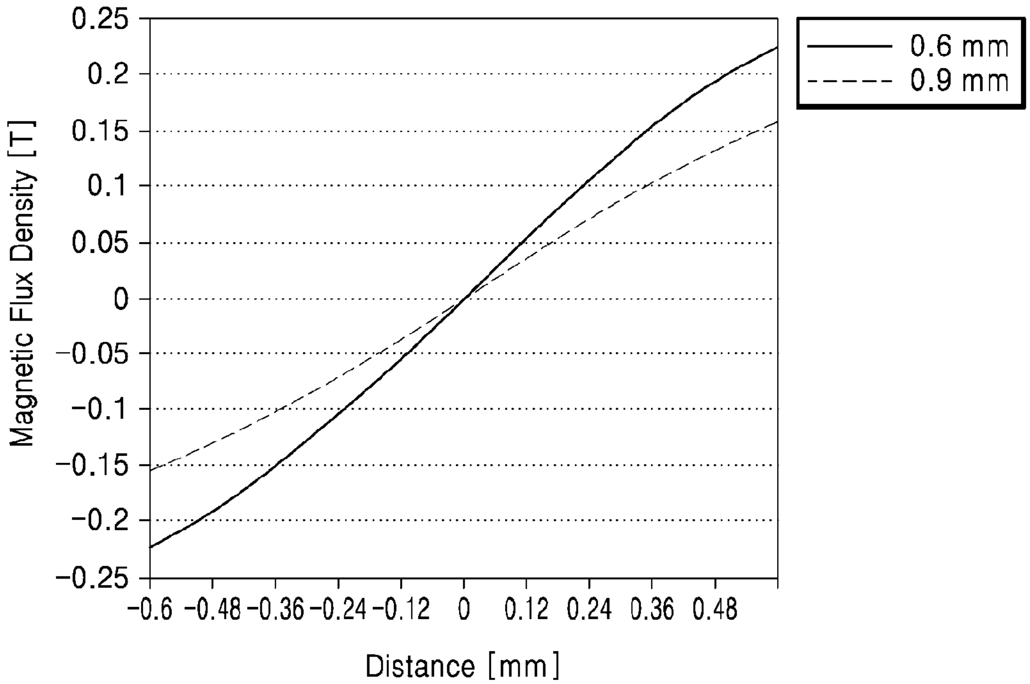


FIG. 12

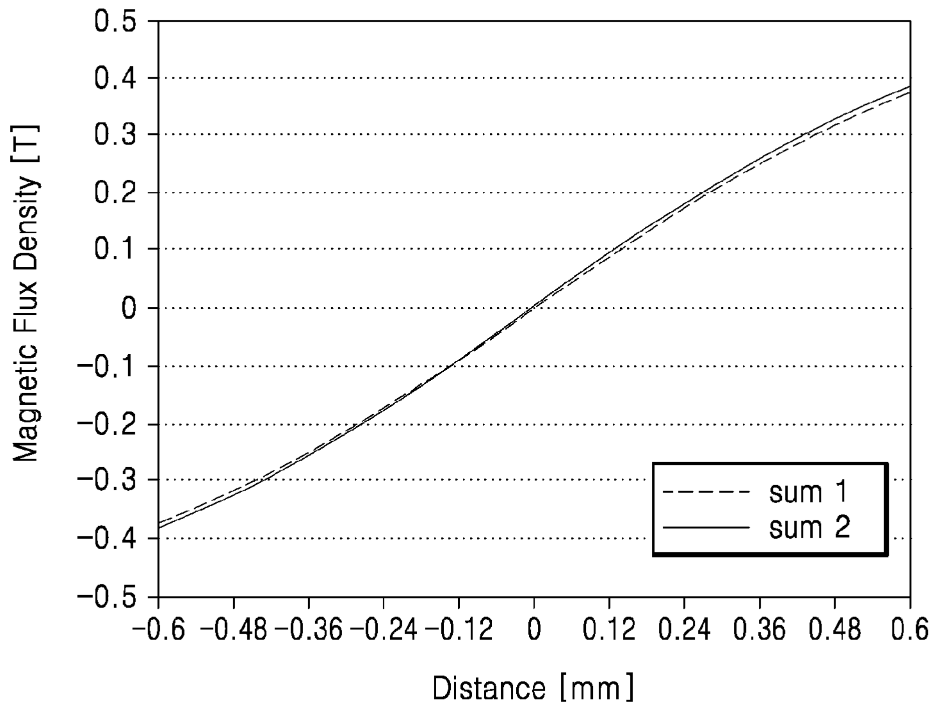

0.5
0.4
0.3
0.2
0.1
0
−0.1
−0.2
−0.3
−0.4
−0.5
Magnetic Flux Density [T]
sum 1
sum 2
−0.6 −0.48 −0.36 −0.24 −0.12 0 0.12 0.24 0.36 0.48 0.6
Distance [mm]

FIG. 13

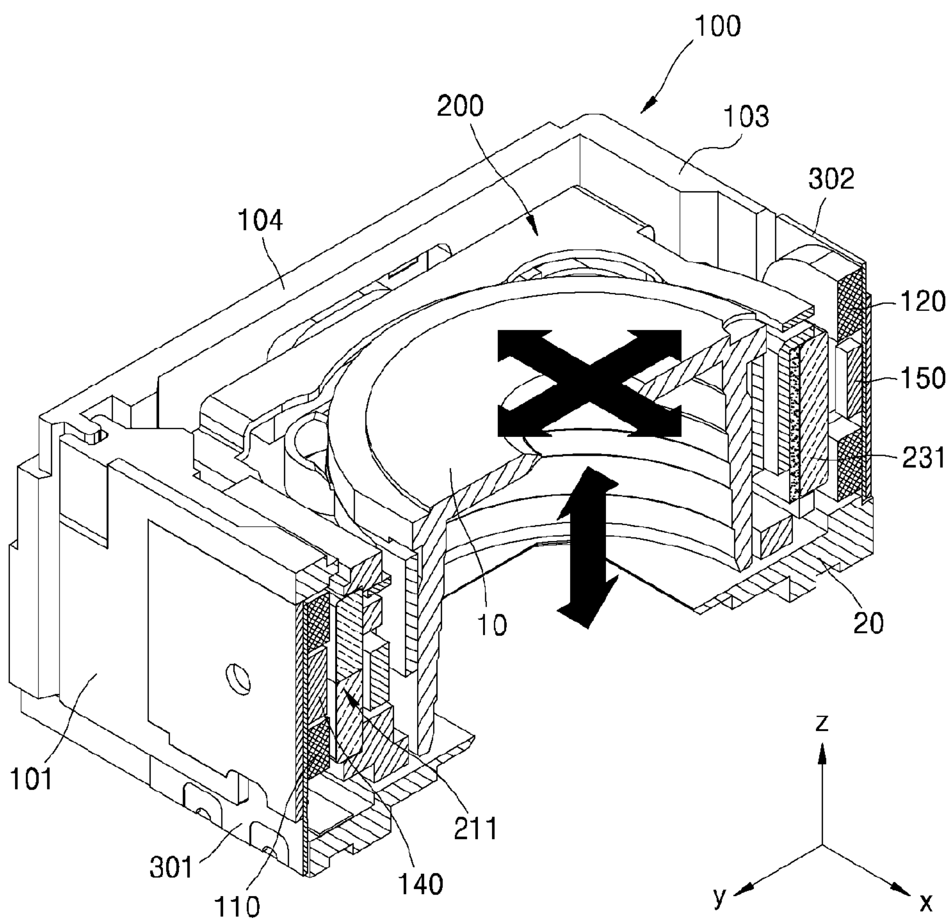
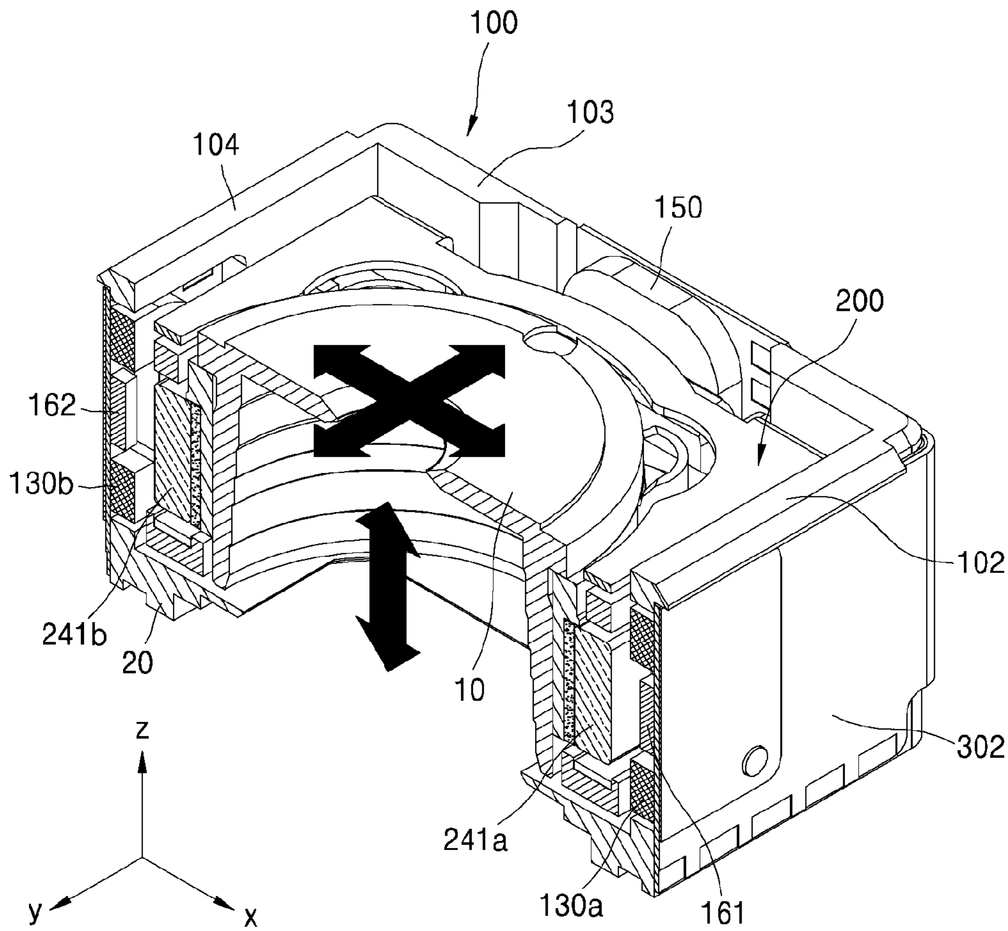


FIG. 14


100
103
104
150
200
162
130b
102
241b
20
10
302
z
241a
y
x
130a
161

CAMERA MODULE HAVING A MOVING FRAME

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of Korean Patent Application No. 10-2013-0098132, filed on Aug. 19, 2013, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

This application is also related to an application being filed concurrently herewith, identified by Ser. No. 14/182,489, entitled "Camera Module, and Position Detector and Position Detection Method Used in the Camera Module", and claiming the benefit of Korean Patent Application No. 10-2013-0098131, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND

One or more embodiments relate to a camera module, and more particularly, to a camera module capable of performing Auto Focus (AF) and optical image stabilization (OIS).

A digital camera is a device capable of storing an image of a subject as a digital file including a picture or a video image. Examples of the digital camera include a digital still camera (DSC), a digital video camera (DVC), and a digital camera module mounted in a mobile phone.

Consumers' demand for high-quality still images and/or videos has considerably increased along with the use of digital photographing apparatuses such as DSCs and/or DVCs. In particular, the demand for a camera module having an Auto Focus (AF) function for automatically adjusting a focus and an optical image stabilization (OIS) function for preventing a decrease in image sharpness due to user' handshaking has increased.

Such a camera module may include a single-axis driving unit that moves a lens barrel along an optical axis to perform an Auto Focus function and a two-axis driving unit that moves the lens barrel in a direction perpendicular to the optical axis. In other words, the camera module may include driving units for moving the lens barrel along three axes. For this purpose, a printed circuit board is used to supply current from the outside to the driving units.

When at least one of the driving units connected to the printed circuit board is moved together with the lens barrel, the printed circuit board connected to the moving driving unit is folded or unfolded. In this process, a predetermined tension variation may be generated in the printed circuit board. In particular, as the size of the camera module has become compact, the variation in tension may obstruct movement of the driving unit connected to the printed circuit board, deteriorating quality of the camera module.

SUMMARY

One or more embodiments disclosed herein include a camera module capable of performing an Auto Focus (AF) function and an Optical Image Stabilization (OIS) function, whereby a lens may be precisely moved, and capable of reducing or preventing a variation in a tension of a printed circuit board.

Additional aspects will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the presented embodiments.

According to one or more embodiments, a camera module includes: a lens barrel including at least one lens group; a moving frame that mounts the lens barrel and moves in an optical axis direction, and in a first direction and a second direction that are perpendicular to the optical axis direction; a fixed frame that movably supports the moving frame and provides the moving frame with a driving force in the optical axis direction, a driving force in the first direction, and a driving force in the second direction; and a base that fixes the fixed frame and includes an image sensor that is spaced apart from the at least one lens group in the optical axis direction.

The fixed frame may include a first driving coil for moving the moving frame in the optical axis direction, a second driving coil for moving the moving frame in the first direction, and third driving coils for moving the moving frame in the second direction, wherein the moving frame includes first, second, and third magnets respectively corresponding to the first, second, and third driving coils.

The camera module may further include a printed circuit board that is electrically connected to the fixed frame.

The printed circuit board may supply a current to the first, second, and third driving coils to move the moving frame.

Tension of the printed circuit board may remain constant while the moving frame moves.

The first, second, and third driving coils may be respectively spaced apart from the first, second, and third magnets in a direction perpendicular to the optical axis direction.

The first, second, and third driving coils may be disposed in sidewalls of the fixed frame.

The fixed frame may include a hole into which at least one of the first, second, and third driving coils is inserted.

The moving frame may include a groove portion into which at least one of the first, second, and third magnets is inserted.

The moving frame may include: a first moving frame that is movably supported by the fixed frame in the optical axis direction; and a second moving frame that is movably supported by the first moving frame in the first and second directions.

A plurality of ball bearings may be disposed between the fixed frame and the first moving frame, wherein a guide groove that guides the plurality of ball bearings in the optical axis direction is formed in at least one of the fixed frame and the first moving frame.

A plurality of ball bearings may be disposed between the first moving frame and the second moving frame, wherein a guide groove that guides the plurality of ball bearings in the first direction or the second direction is formed in at least one of the first moving frame and the second moving frame.

The second moving frame may include: a first sub-moving frame that is moved in the first direction, wherein the second magnet is disposed at a side of the first sub-moving frame; and a second sub-moving frame that is moved in the second direction, wherein the third magnets are disposed at two sides of the second sub-moving frame.

The second sub-moving frame may be movably supported by the first sub-moving frame in the second direction, and the first sub-moving frame may be movably supported by the first moving frame in the first direction.

A plurality of ball bearings may be disposed between the first sub-moving frame and the second sub-moving frame, wherein a guide groove that guides the plurality of ball bearings in the second axis direction is formed in at least one of the first sub-moving frame and the second sub-moving frame.

A plurality of ball bearings may be disposed between the first sub-moving frame and the first moving frame, wherein a guide groove that guides the plurality of ball bearings in the first direction is formed in at least one of the first sub-moving frame and the first moving frame.

The first sub-moving frame may include a detour portion to make a detour with respect to the third magnets. The detour portion and the third magnets may be spaced apart from each other.

The first moving frame may include a yoke that is disposed to correspond to the third magnets in order to prevent the second moving frame from detaching therefrom.

The fixed frame may include first, second, and third sensors that correspond to the first, second, and third magnets, respectively.

The first, second, and third sensors may be magnetic sensors.

The first sensor may detect a position of the first magnet in the optical axis direction.

The second sensor may detect a position of the second magnet in the first direction.

The third sensors may detect a position of the third magnets in the second direction.

The third magnets may be disposed at two sides in the first direction of the second moving frame, wherein the third sensors are disposed at two sides in the first direction of the fixed frame.

A position of the moving frame in the second direction may be detected based on a first detection signal detected by one of the third sensors and a second detection signal detected by other of the third sensors.

A position of the moving frame in the second direction may be detected based on a third detection signal which is a sum of the first detection signal and the second detection signal.

A sum of a distance between one of the third sensors and one of the third magnets in the first direction and a distance between the other of the third sensors and the other of the third magnets may be constant.

BRIEF DESCRIPTION OF THE DRAWINGS

These and/or other aspects will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings in which:

FIG. **1** is an assembled perspective view of a camera module according to an embodiment;

FIG. **2** is an exploded perspective view illustrating the camera module of FIG. **1** according to an embodiment;

FIG. **3** is an exploded perspective view of a moving frame of FIG. **2**, according to an embodiment;

FIG. **4** is an exploded perspective view of a fixed frame of FIG. **2**, according to an embodiment;

FIG. **5** is a conceptual block diagram illustrating a first magnet and a first sensor, according to an embodiment;

FIG. **6** is a graph showing a magnetic flux density of a first magnet in an optical axis direction, according to an embodiment;

FIG. **7** is a graph showing a magnetic flux density detected as a first magnet is moved in an optical axis direction while the first magnet and a first sensor are spaced apart from each other in a second direction by a distance of 0.6 mm, according to an embodiment;

FIG. **8** is a graph showing a magnetic flux density detected by a third magnetic sensor as the third magnet is moved in the second direction, when a distance between the third magnet and the third sensor is varied in the first direction, according to an embodiment;

FIG. **9** is a plan view of the camera module of FIG. **2** illustrating a second sub-moving frame, according to an embodiment;

FIGS. **10**A and **10**B are plan views of the camera module illustrating a second sub-moving frame of FIG. **9** moved in a first direction, according to various embodiments;

FIG. **11**A is a graph showing a magnetic flux density detected by a third sensor of FIG. **10**A according to a position of the third magnet in a second direction, and FIG. **11**B is a graph showing a magnetic flux density detected by the third sensor of FIG. **10**B according to a position of the third magnet in the second direction;

FIG. **12** is a graph showing a third magnetic flux density which is a sum of first and second magnetic flux densities detected by third sensors illustrated in FIGS. **11**A and **11**B, according to a position of a second sub-moving frame in a second direction, according to an embodiment;

FIG. **13** is a cross-sectional perspective view of the camera module of FIG. **1** cut along a line XIII-XIII'; and

FIG. **14** is a cross-sectional perspective view of the camera module of FIG. **1** cut along a line XIV-XIV'.

DETAILED DESCRIPTION

Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. In this regard, the present embodiments may have different forms and should not be construed as being limited to the descriptions set forth herein. Accordingly, the embodiments are merely described below, by referring to the figures, to explain aspects of the present description. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. Expressions such as "at least one of," when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list.

It will be understood that, although the terms "first", "second", "third" etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another.

FIG. **1** is an assembly view of a camera module according to an embodiment.

Referring to FIG. **1**, the camera module may include a lens barrel **10** including at least one lens group **11**, a moving frame **200** that mounts (or includes) the lens barrel **10** to move the lens barrel **10** in an optical axis direction (z-axis direction) and in first and second directions (x-axis and y-axis directions) that are perpendicular to the optical axis direction (z-axis), a fixed frame **100** that movably supports the moving frame **200**, and a print circuit board **300** that supplies a current to move the moving frame **200**. The second direction (y-axis direction) may be orthogonal to the first direction (x-axis direction), but is not limited thereto.

The moving frame **200** may be driven along the optical axis direction (z-axis direction), the first direction (x-axis direction), and the second direction (y-axis direction). Accordingly, an Auto Focus (AF) function of automatically adjusting a focus on an image sensor **21** (see FIG. **11**) and an optical image stabilizer (OIS) function of preventing a decrease in an image quality due to vibration such as hand shaking may be performed. The moving frame **200** performs the Auto Focus function by moving the lens barrel **10** along the optical axis direction (z-axis direction), and also perform the OIS function by moving the lens barrel **10** two-dimensionally along directions (x-axis direction and y-axis direction) that are perpendicular to the optical axis direction (z-axis).

The printed circuit board **300** provides the fixed frame **100** with a current for three-axis driving of the moving frame **200**. The printed circuit board **300** may drive the moving frame **200** along three axes by providing a current to the fixed frame **100**. The printed circuit board **300** may be a flexible printed circuit board.

If the printed circuit board **300** provides a current to the moving frame **200** and not to the fixed frame **100**, the printed circuit board **300** may be folded or unfolded while the moving frame **200** is moved. Accordingly, the printed circuit board **300** may be damaged or a tension applied to the printed circuit board **300** may vary. The tension variation may hinder an accurate movement of the moving frame **200**.

However, according to the current embodiment, the printed circuit board **300** provides a current not to the moving frame **200** but to the fixed frame **100**, thereby preventing folding or unfolding of the printed circuit board **300** due to movement of the moving frame **200**. As there is no tension variation in the printed circuit board **300**, the moving frame **200** may be accurately moved. Hereinafter, a structure in which an electrical connection is provided not to the moving frame **200** but to the fixed frame **100** via the printed circuit board **300** of the camera module will be described in detail.

FIG. **2** is an exploded perspective view illustrating the camera module of FIG. **1**. FIG. **3** is an exploded perspective view of the moving frame **200** of FIG. **2**, according to an embodiment. FIG. **4** is an exploded perspective view of the fixed frame **100** of FIG. **2**, according to an embodiment.

Referring to FIGS. **2** through **4**, the camera module includes a base **20**, the fixed frame **100** fixed to the base **20**, a first moving frame **210** that is movably supported by the fixed frame **100** in an optical axis direction (z-axis direction), a second moving frame **220** that is movably supported by the first moving frame **210** in a direction perpendicular to the optical axis direction, a cover **30** covering an upper portion of the second moving frame **220**, and a printed circuit board **300** that is disposed at a side portion of the fixed frame **100**.

The base **20** is disposed under the fixed frame **100**, and an image sensor **21** may be included in a central portion of the base **20**. The lens barrel **10** may be spaced apart from the image sensor **21** in the optical axis direction (z-axis direction).

The fixed frame **100** is fixed to the base **20**. As the fixed frame **100** is fixed to the base **20**, relative positions of the fixed frame **100** and the base **20** do not vary with respect to each other. Also, the fixed frame **100** may be directly fixed to the base **20** as illustrated in FIGS. **2** through **4**, or the fixed frame **100** may be indirectly fixed to the base **20** via another member.

The fixed frame **100** movably supports the moving frame **200**, and provides a driving force to the moving frame **200** in the optical axis direction (z-axis direction) and in a first direction (x-axis direction) and a second direction (y-axis direction).

The fixed frame **100** may include first through fourth sidewalls **101**, **102**, **103**, and **104** that surround side portions of the moving frame **200**. The four sidewalls **101**, **102**, **103**, and **104** of the fixed frame **100** respectively include first and second driving coils **110** and **120** and third driving coils **130***a* and **130***b* For example, the first driving coil **110** for moving the first moving frame **210** in the optical axis direction (z-axis direction) is included in a hole **101***a* of the first sidewall **101**, the second driving coil **120** for moving the second moving frame **220** in the first direction (x-axis direction) is included in a hole **103***a* of the third sidewall **103**, and the third driving coils **130***a* and **130***b* for moving the second moving frame **220** in the second direction (y-axis direction) are included in holes **102***a* and **104***a* of the second and fourth sidewalls **102** and **104**. By including the third driving coils **130***a* and **130***b* in the second and fourth sidewalls **102** and **104**, the second moving frame **220** may be stably moved in the second direction (y-axis direction). The first and second driving coils **110** and **120** and the third driving coils **130***a* and **130***b* receive a current from the printed circuit board **300** to move the first and second moving frame **210** and **220**. The first and second moving frames **210** and **220** are disposed inside the fixed frame **100**.

The first moving frame **210** is moved in the fixed frame **100** in the optical axis direction (z-axis direction). A first magnet **211** may be disposed in the first moving frame **210** to correspond to the first driving coil **110**. The first magnet **211** includes an N-pole and an S-pole arranged along the optical axis direction (z-axis direction). The first magnet **211** may be a permanent magnet that generates a magnetic force without use of an additional power supply.

The first moving frame **210** may be movably supported by the fixed frame **100** in the optical axis direction (z-axis direction). A plurality of ball bearings B**1** may be arranged between the first moving frame **210** and the fixed frame **100**. A guide groove **213** that guides the ball bearings B**1** to be moved along the optical axis direction (z-axis direction) may be formed in at least one of the first moving frame **210** and the fixed frame **100**. The guide groove **213** is extended in the optical axis direction (z-axis direction), and may be used to remove a force that is applied to the ball bearings B**1** in another direction different from the optical axis direction (z-axis direction). Accordingly, the first moving frame **210** may be moved accurately in the optical axis direction (z-axis direction).

The first moving frame **210** may have an L-shaped cross-section. The first moving frame **210** includes a first region **210***a* that is parallel to the optical axis direction (z-axis direction) and a second region **210***b* that is perpendicular to the optical axis direction (z-axis direction). The first magnet **211** and a groove portion **212** into which the first magnet **211** is to be inserted may be formed in the first region **210***a*. A second region **210***b* movably supports the second moving frame **220** in a direction perpendicular to an optical axis. In the second region **210***b*, a yoke **215** for preventing detachment of the second moving frame **220** therefrom may be included.

The second moving frame **220** is moved in a direction perpendicular to the optical axis in the fixed frame **100**. For example, the second moving frame **220** may be movably supported in the first moving frame **210** in a direction perpendicular to the optical axis. The second moving frame **220** may include a mounting portion I in which the lens barrel **10** may be mounted and second magnets **231** and third magnets **241***a* and **241***b* disposed around a circumference of the mounting portion I to respectively correspond to the second driving coils **120** and the third driving coils **130***a*, and **130***b*. The second magnet **231** includes an N-pole and an S-pole arranged in the first direction (x-axis direction) perpendicular to the optical axis. The third magnets **241***a* and **241***b* each include an N-pole and an S-pole arranged in the second direction (y-axis direction) perpendicular to the optical axis. The arrangement directions of the N-pole and the S-pole of the second magnets **231** and the third magnets

241*a* and 241*b* may be perpendicular to the arrangement direction of the N-pole and the S-pole of the first magnet **211**. According to this arrangement, the first and second magnets **211** and **231** and the third magnets **241***a* and **241***b* may be disposed at a side portion of the moving frame **200**, and may move the first and second moving frames **210** and **220** along three axes. The second magnet **231** and the third magnets **241***a* and **241***b* may each be a permanent magnet that generates a magnetic force without use of an additional power supply.

The second moving frame **220** may include a first sub-moving frame **230** and a second sub-moving frame **240**. The first sub-moving frame **230** may be movably supported by the first moving frame **210** in the first direction (x-axis direction). A plurality of ball bearings B**2** may be disposed between the first sub-moving frame **230** and the first moving frame **210**. A guide groove **214** that guides the ball bearings B**2** to move in the first direction (x-direction) may be formed in at least one of the first sub-moving frame **230** and the first moving frame **210**. The guide groove **214** is extended in the first direction (x-axis direction), and may remove a force that is applied to the ball bearings B**1** in another direction different from the first direction (x-direction). Accordingly, the first sub-moving frame **230** may be accurately moved along the first direction (x-direction). A groove portion **232** into which the second magnet **231** is inserted is formed in the first sub-moving frame **230**, and a detour portion **230***a* that prevents interference of the first sub-moving frame **230** with the third magnets **241***a* and **241***b* may also be formed in the first sub-moving frame **230**. When the third magnets **241***a* and **241***b* are moved in the second direction (Y-axis direction), the detour portion **230***a* may be spaced apart from the third magnets **241***a* and **241***b* to not obstruct movement of the third magnets **241***a* and **241***b*. For example, if the third magnets **241***a* and **241***b* are set to move about 0.2 mm in the second direction (y-axis direction), a distance between the detour portion **230***a* and the third magnets **241***a* and **241***b* may be about 0.4 mm.

The second sub-moving frame **240** may be movably supported by the first sub-moving frame **230** in the second direction (y-axis direction). A plurality of ball bearings B**3** may be disposed between the second sub-moving frame **240** and the first sub-moving frame **230**. A guide groove **233** that guides the ball bearings B**3** to move in the second direction (y-axis direction) may be formed in at least one of the second sub-moving frame **240** and the first sub-moving frame **230**. The guide groove **233** is extended in the second direction (y-axis direction), and may remove a force that is applied to the ball bearings B**1** in another direction different from the second direction (y-axis direction). Accordingly, the second sub-moving frame **240** may be accurately moved in the second direction (y-axis direction). A groove portion **242** into which the third magnets **241***a* and **241***b* are to be inserted may be formed in the second sub-moving frame **240**.

The fixed frame **100** is electrically connected to the printed circuit board **300**. Accordingly, the first, second, and third driving coils **110**, **120**, **130***a*, and **130***b* included in the fixed frame **100** receive a current to move the first and second moving frames **210** and **220**.

When a current is supplied to the first and second coils **110** and **120** and the third driving coils **130***a*, **130***b*, the first and second magnets **211** and **231** and third magnets **241***a* and **241***b* corresponding thereto move in a predetermined direction according to the Fleming left hand rule. When a current is supplied to the first driving coil **110**, the first magnet **211** is moved in the optical axis direction (z-axis direction). The first magnet **211** may be moved in a positive direction or a negative direction of the optical axis direction (z-axis direction) according to a direction that the current is supplied to the first driving coil **110**. When a current is supplied to the second driving coil **120**, the second magnet **231** is moved in a positive direction or a negative direction of the first direction (x-axis direction) that is perpendicular to the optical axis. When a current is supplied to the third driving coils **130***a* and **130***b*, the third magnets **241***a* and **241***b* are also moved in a positive direction or a negative direction of the second direction (y-axis direction) that is perpendicular to the optical axis.

The printed circuit board **300** is electrically connected to the fixed frame **100**. For example, a first printed circuit board **301** is connected to the first driving coil **110**, and a second printed circuit board **302** is connected to second driving coil **120** and the third driving coils **130***a* and **130***b*. First and second plates P**1** and P**2** for connecting the printed circuit board **300** to the first and second driving coils **110** and **120** and the third driving coils **130***a* and **130***b* may be disposed outside the printed circuit board **300**. The first plate P**1** may be disposed on the outside of the first printed circuit board **301**, and the second plate P**2** may be disposed on the outside of the second printed circuit board **302**. The first and second plates P**1** and P**2** may be formed of various materials such as stainless steel.

As described above, by disposing the first and second magnets **211** and **231** and the third magnets **241***a* and **241***b* which are not needed to be electrically connected, to the moving frame **200** that is moved along three axes and disposing the first and second driving coils **110** and **120** and the third driving **130***a* and **130***b* which are needed to be electrically connected, to the fixed frame **100** fixed to the base **20**, the printed circuit board **300** that is electrically connected to the fixed frame **100** does not interfere with a movement of the moving frame **200**. Accordingly, the moving frame **200** may be moved accurately.

First and second sensors **140** and **150** and third sensors **161** and **162** that sense a movement of the moving frame **200** may be included in the first through fourth sidewalls **101**, **102**, **103**, and **104** of the fixed frame **100**. For example, the first sensor **140** is included in the first sidewall **101** to sense a movement of the first magnet **211** in the optical direction (z-axis direction) and the second sensor **150** is included in the third sidewall **103** to sense a movement of the second magnet **231** in the first direction (x-axis direction), and the third sensors **161** and **162** may be included in the second and fourth sidewalls **102** and **104** to sense a movement of the third magnets **241***a* and **241***b* in the second direction (y-axis direction).

The first and second sensors **140** and **150** and the third sensors **161** and **162** may be magnetic sensors that may output an electrical signal in proportion to a magnetic field of a magnet by using a Hall effect, thereby sensing a movement of the first and second magnets **211** and **231** and the third magnets **241***a* and **241***b* and the moving frame **200** in which the first and second magnets **211** and **231** and the third magnets **241***a* and **241***b* are installed.

The first and second sensors **140** and **150** and the third sensors **161** and **162** may detect positions of the first and second magnets **211** and **231** and the third magnets **241***a* and **241***b* used in moving the moving frame **200**. Accordingly, there is no need to install an additional magnet for position detection, and thus, a structure of the camera module may be simplified.

The first sensor **140** may determine position movement of the first magnet **211** in the optical axis direction (z-axis direction). FIG. **5** is a conceptual block diagram illustrating a first magnet and a first sensor, according to an embodiment. The principle of detecting a position of the first magnet **211** via the first sensor **140** will be briefly described with reference to FIG. **5**.

The first magnet **211** may be moved in the optical axis direction (z-axis direction). As the first magnet **211** is moved in the optical axis direction (z-axis direction), a distance c between a center of the first magnet **211** and a center of the first sensor **140** in the optical axis direction (z-axis direction) may vary. The first magnet **211** has an N-pole and an S pole arranged in the optical axis direction (z-axis direction), and thus, the first magnet **211** may have a predetermined magnetic flux density in the optical axis direction (z-axis direction) as shown in FIG. **6**. As the first magnet **211** is moved in the optical axis direction (z-axis direction) with respect to the first sensor **140**, a detection signal detected by the first sensor **140**, for example, a magnetic flux density, varies.

FIG. **7** is a graph showing a magnetic flux density detected by the first sensor **140** while the first magnet **211** that is spaced apart from the first sensor **140** by a predetermined distance a, for example, 0.6 mm, in the second direction (y-axis direction), and is moved in the optical axis direction (z-axis direction). Referring to FIG. **7**, a first magnetic flux density detected by using the first magnetic sensor **211** has a predetermined value according to the distance c between the center of the first magnet **211** and the center of the first sensor **140** in the optical axis direction (z-axis direction). For example, if the distance c between the center of the first magnet **211** and the center of the first sensor **140** along the optical axis direction (z-axis direction) is 0, a first magnetic density detected by the first sensor **140** is 0 T(tesla), and if the distance c between the center of the first magnet **211** and the center of the first sensor **140** along the optical axis direction (z-axis direction) is 0.12 mm, a first magnetic density detected by the first sensor **140** may be 0.05 T. On the other hand, if the distance c between the center of the first magnet **211** and the center of the first sensor **140** along the optical axis direction (z-axis direction) is −0.12 mm, the first magnetic density detected by the first sensor **140** may be −0.05 T. That is, the first magnetic flux density detected by the first sensor **140** may be determined according to a position of the first magnet **211** along the optical axis direction (z-axis direction). Thus, a position of the first magnet **211** along the optical axis direction (z-axis direction) may be determined based on the first magnetic flux density detected by the first sensor **140**.

In the above description about the determination of a position of the first magnet **211** along the optical axis direction (z-axis direction), it is assumed that the distance a between the first magnet **211** and the first sensor **140** along the second direction (y-axis direction) is constant. Referring to FIGS. **2** through **4** again, the first moving frame **210** in which the first magnet **211** is included is moved only in the optical axis direction (z-axis direction) with respect to the fixed frame **100**, in which the first sensor **140** is included, via the guide groove **213**, and thus, the distance a between the first magnet **211** and the first sensor **140** in the second direction (y-axis direction) is constant. A position movement of the first magnet **211** in the optical axis direction (z-axis direction) may be determined based on a magnetic flux density detected by the first sensor **140** which is spaced apart from the first magnet **211** in the second direction (y-axis direction) by a constant distance. Accordingly, the first sensor **140** may determine a position movement of the first moving frame **210**, in which the first magnet **211** is included, in the optical axis direction (z-axis direction).

The second sensor **150** may determine a position movement of the second magnet **231** in the first direction (x-axis direction). The first sub-moving frame **230** in which the second magnet **231** is included is moved in the first direction (x-axis direction) with respect to the first moving frame **210** via the guide groove **214**. The first sub-moving frame **210** is not capable of moving in the second direction (y-axis direction) with respect to the first moving frame **210**, and thus, a distance between the second sensor **150** installed in the fixed frame **100** and the second magnet **231** included in the first sub-moving frame **230** in the second direction (y-axis direction) is constant. The same as above, a position movement of the second magnet **231** in the first direction (x-axis direction) may be determined based on a magnetic flux density detected by the second sensor **150** which is spaced apart from the second magnet **231** by a constant distance in the second direction (y-axis direction). Accordingly, the second sensor **150** may determine a position of the first sub-moving frame **230** in which the second magnet **231** is included.

The third sensors **161** and **162** may determine a position movement of the pair of third magnets **241***a* and **241***b* in the second direction (y-axis direction). The second sub-moving frame **240** in which the third magnets **241***a* and **241***b* are included is moved in the second direction (y-axis direction) with respect to the first sub-moving frame **230** via the guide groove **233**. The second sub-moving frame **240** is not capable of moving in the first direction (x-axis direction) with respect to the first sub-moving frame **230**, but the first sub-moving frame **230** which movably supports the second sub-moving frame **240** may be moved in the first direction (x-axis direction) as described above. Accordingly, when the first sub-moving frame **230** is moved in the first direction (x-axis direction), the second sub-moving frame **240** is moved in the first direction, and consequently, the third magnets **241***a* and **241***b* are moved in the first direction (x-axis direction). Accordingly, the distance between the third magnet **241***a* the third sensor **161** and the distance between the third magnet **241***b* and the third sensor **162** varies.

FIG. **8** is a graph showing a magnetic flux density detected by the third magnetic sensor **161** as the third magnet **241***a* is moved in the second direction (y-axis direction), when the distance a between the third magnet **241***a* and the third sensor **161** varies in the first direction (x-axis direction). Referring to FIG. **8**, the magnetic flux density detected by the third sensor **161** as the third magnet **241***a* is moved along the second direction (y-axis direction) varies according to the distance between the third magnet **241***a* and the third sensor **161** along the first direction (x-axis direction). For example, when the distance between the third magnet **241***a* and the third sensor **161** in the first direction (x-axis direction) was 0.6 mm, 0.7 mm, 0.8 mm, and 0.9 mm, and the third magnet **241** has moved from the third sensor **161** by 0.6 mm in the second direction (y-axis direction), a magnetic density detected by using the third sensor **161** was about 0.225 T, about 0.2 T, about 0.175 T, and about 0.16 T, respectively. That is, even though the third magnet **241***a* is disposed at the same position along the second direction (y-axis direction), if the distance between the third magnet **241***a* and the third sensor **161** along the first direction (x-axis direction) varies, the magnetic flux density detected by the third sensor **161** is not constant. Accordingly, if a position of the third magnet **241***a* along the second direction (y-axis direction) is determined only by the magnetic flux density detected by the third sensor **161**, a significant error may occur.

In view of this, according to the current embodiment, the third sensors **161** and **162** that are spaced apart from each other by a predetermined distance are disposed on two sides of the pair of third magnets **241***a* and **241***b* in the first direction (x-axis direction), and a position of the third magnets **241***a* and **241***b* in the second direction (y-axis direction) may be determined based on a magnetic flux density detected by the third sensors **161** and **162**.

FIG. **9** is a plan view of the camera module of FIG. **2** illustrating the second sub-moving frame **240**, according to an embodiment. FIGS. **10**A and **10**B are plan views that illustrate the second sub-moving frame **240** of FIG. **9** moved in the first direction (x-axis direction), according to embodiments.

Referring to FIG. **9**, the second sub-moving frame **240** mounts the lens barrel **10** and is moved in the first direction and the second direction. The second sub-moving frame **240** includes third magnets **241***a* and **241***b* disposed at two sides in the first direction (x-axis direction). The fixed frame **100** includes third sensors **161** and **162** spaced apart from each other in the first direction (x-axis direction) to respectively correspond to the third magnets **241***a* and **241***b*. The third sensors **161** and **162** are spaced apart from each other by a predetermined distance. When a distance between the third magnet **241***a* and the third sensor **161** in the first direction (x-axis direction) is a**1**, and a distance between the other third magnet **241***b* and the other third sensor **162** in the first direction (x-axis direction) is b**1**, the distances a**1** and b**1** vary according to movement of the second sub-moving frame **240** in the first direction (x-axis direction). However, a sum of a**1**+b**1** remains constant.

Referring to FIG. **10**A, the second sub-moving frame **240** is moved in the first direction (x-axis direction) such that the third magnet **241***a* may be spaced apart from the third sensor **161** in the first direction (x-axis direction) by 0.7 mm, and the third magnet **241***b* may be spaced apart from the third sensor **162** in the first direction (x-axis direction) by 0.8 mm. Referring to FIG. **10**B, the second sub-moving frame **240** is moved in the first direction (x-axis direction) such that the third magnet **241***a* may be spaced apart from the third sensor **161** in the first direction (x-axis direction) by 0.6 mm, and the third magnet **241***b* may be spaced apart from the third sensor **162** in the first direction (x-axis direction) by 0.9 mm.

FIG. **11**A is a graph showing a magnetic flux density detected by the third sensors **161** and **162** of FIG. **10**A according to positions of the third magnets **241***a* and **241***b* in the second direction (y-axis direction), and FIG. **11**B is a graph showing a magnetic flux density detected by the third sensors **161** and **162** of FIG. **10**B according to position of the third magnets **241***a* and **241***b* in the second direction (y-axis direction). FIG. **12** is a graph showing a third magnetic flux density which is a sum of first and second magnetic flux densities detected by the third sensors **161** and **162** illustrated in FIGS. **11**A and **11**B, according to a position of the second sub-moving frame **240** in the second direction (y-axis direction), according to an embodiment.

Referring to FIGS. **11**A and **11**B, according to the position of the second sub-moving frame **240** in the second direction (y-axis direction), patterns of the first and second magnetic flux densities detected by the third **161** and **162** vary according to distances between the third sensors **161** and **162** and the third magnets **241***a* and **241***b* in the first direction (x-axis direction). For example, a pattern of the first magnetic flux density detected by the third sensor **161** when the distance between the third sensor **161** and the third magnet **241***a* along the first direction (x-axis direction) is 0.7 mm is different from a pattern of the second magnetic flux density detected by the third sensor **162** when the distance between the third sensor **162** and the third magnet **241***b* in the first direction (x-axis direction) is 0.8 mm. Also, a pattern of the first magnetic flux density detected by the third sensor **161** when the distance between the third sensor **161** and the third magnet **241***a* along the first direction (x-axis direction) is 0.9 mm is different from a pattern of the second magnetic flux density detected by the third sensor **162** when the distance between the third sensor **162** and the third magnet **241***b* along the first direction (x-axis direction) is 0.9 mm.

However, referring to FIG. **12**, the third magnetic density (sum**1**, sum**2**) which is a sum of the magnetic flux densities detected by the third sensors **161** and **162** exhibit substantially the same patterns, regardless of the position of the second sub-moving frame **240** along the first direction (x-axis direction). The third magnetic flux density (sum**1**) is a sum of the first magnetic flux density detected by the third sensor **161** and the second magnetic flux density detected by using the third sensor **162** of FIG. **11**A, and the third magnetic flux density (sum**2**) is a sum of the first magnetic flux density detected by the third sensor **161** and the second magnetic flux density detected by the third sensor **162** of FIG. **11**B. The third magnetic flux density (sum**1**, sum**2**) which is a sum of the first magnetic flux density and the second magnetic flux density has a constant value regardless of a movement of the first magnet **211** in the first direction (x-axis direction). The third magnetic flux density (sum**1**, sum**2**) having a constant value according to a position of the third magnets **241***a* and **241***b* in the second direction (y-axis direction) means that even when the third magnets **241***a* and **241***b* are moved in the first direction (x-axis direction), an error of the third magnetic flux density detected at the same position in the second direction (y-axis direction) is less than up to 2.9%.

Thus, even when the third magnets **241***a* and **241***b* are located at different positions in the first direction (x-axis direction) as illustrated in FIGS. **8**A and **8**B, a third magnetic flux density which is a sum of magnetic flux densities detected by the third sensor **161** and the third sensor **162** is constant according to a position of the third magnets **241***a* and **241***b* in the second direction (y-axis direction).

Accordingly, a position information generating unit (not shown) may compare the third magnetic flux density which is the sum of the first magnetic flux density detected by the third sensor **161** and the second magnetic flux density detected by the third sensor **162** with a predetermined reference value, thereby generating position information of the third magnets **241***a* and **241***b* in the second direction (y-axis direction). For example, the position information generating unit may compare the third magnetic flux density which is the sum of the first magnetic flux density detected by the third sensor **161** and the second magnetic flux density detected by using the third sensors **162** with a predetermined reference value according to the position of the third magnets **241***a* and **241***b* in the second direction (y-axis direction), thereby generating or determining position information of the third magnets **241***a* and **241***b* in the second direction (y-axis direction). As the third magnets **241***a* and **241***b* are fixed to the second sub-moving frame **240**, position information of the second sub-moving frame **240** may be generated or determined based on position information of the third magnets **241***a* and **241***b* in the second direction (y-axis direction). The reference value may be a preset value based on the third magnetic flux density in the second direction illustrated in FIG. **10**.

The position information generating unit may include a memory unit that stores a preset reference value according to movement of the third magnets **241***a* and **241***b* in the second direction (y-axis direction) and a position determining unit that determines position information of the third magnets **241***a* and **241***b* along the second direction (y-axis direction) by comparing the third magnetic flux density with the reference value.

A magnetic flux density is used as an example of a detection signal detected by a magnetic sensor in the current embodiment. However, an electrical signal or the like may also be used.

Table 1 below shows results of a position movement of the moving frame **200** of the camera module of FIG. **2** in a positive direction or a negative direction of the second direction (y-axis direction). A current was supplied to the third driving coils **130***a* and **130***b* to move the third magnets **241***a* and **241***b* in a positive direction of the second direction (y-axis direction) nine times and in a negative direction of the second direction (y-axis direction) nine times when the moving frame **200** was at a reference position (Offset=0 um), when the moving frame **200** was spaced apart from the reference position a distance of +100 um in the first direction (x-axis direction) (Offset=+100 um), and when the moving frame **200** was spaced apart from the reference position a distance of −100 um in the first direction (x-axis direction) (Offset=−100 um), respectively. When moving the third magnets **241***a* and **241***b* in the second direction (y-axis direction), position information of the third magnets **241***a* and **241***b* in the second direction (y-axis direction) generated based on the sum of detection signals detected by the third sensors **161** and **162** was used.

TABLE 1

	Moving distance [um] of moving frame in the second direction when Offset = 0 um		Moving distance [um] of moving frame in the second direction when Offset = +100 um		Moving distance [um] of moving frame in the second direction when Offset = −100 um	
Frequency	positive direction	negative direction	positive direction	positive direction	negative direction	positive direction
1	10	9	10	10	9	10
2	9	10	10	11	9	9
3	9	9	11	11	10	9
4	10	9	11	10	8	9
5	9	10	11	11	9	10
6	11	9	10	10	9	9
7	11	9	10	10	10	8
8	10	8	11	11	10	9
9	9	8	9	10	10	9
Average	9.8	9.0	10.3	10.4	9.3	9.1

Referring to Table 1, even when a position of the moving frame **200** varies in the first direction (x-axis direction), when a predetermined current was applied to the third driving coils **130***a* and **130***b*, the moving frame **200** was moved uniformly within a range of about 8 to 11 um which is a predetermined range in the second direction (y-axis direction). An average distance was about 9.0 um to about 10.4 um.

Regarding the uniform position movement of the moving frame **200** in the second direction (y-axis direction) as shown in Table 1, it is assumed that an accurate position detection of the moving frame **200** takes place in the second direction (y-axis direction). Accordingly, based on the uniform position movement of the moving frame **200** in the second direction (y-axis direction) in a predetermined range, it may be indirectly confirmed that positions of the third magnets **241***a* and **241***b* may be accurately detected based on the sum of detection signals detected by the third sensors **161** and **162**.

FIG. **13** is a cross-sectional perspective view of the camera module of FIG. **1** cut along a line XIII-XIII'; and FIG. **14** is a cross-sectional perspective view of the camera module of FIG. **1** cut along a line XIV-XIV'.

Referring to FIG. **13**, the first driving coil **110** and the first sensor **140** are included in the first sidewall **101** of the fixed frame **100**, and the first magnet **211** is disposed in the moving frame **200** to correspond to the first driving coil **110** and the first sensor **140**. The first driving coil **110** and the first magnet **211** are spaced apart from each other in the second direction (y-axis direction) perpendicular to an optical axis. Also, the second driving coil **120** and the second sensor **150** are included in the third sidewall **103** of the fixed frame **100**, and the second magnet **231** is disposed in the moving frame **200** to correspond to the second driving coil **120** and the second sensor **150**. The second driving coil **120** and the second sensor **150** are also spaced apart from each other in the second direction (y-axis direction) perpendicular to the optical axis. The first driving coil **110** and the first sensor **140** are electrically connected to the first printed circuit board **301**, and the second driving coil **120** and the second sensor **150** are electrically connected to the second printed circuit board **302**.

Referring to FIG. **14**, the third driving coils **130***a* and **130***b* and the third sensors **161** and **162** are included the second sidewall **102** and the fourth sidewall **104** of the fixed frame **200**, respectively, and the third magnets **241***a* and **241***b* are disposed in the moving frame **200** to correspond to the third driving coils **130***a* and **130***b* and the third sensors **161** and **162**. The third driving coils **130***a* and **130***b* and the third magnets **241***a* and **241***b* are spaced apart from each other in the first direction (x-axis direction) that is perpendicular to the optical axis. The pair of the driving coils **130***a* and **130***b* and the pair of the third sensors **161** and **162** are electrically connected to the second printed circuit board **302**.

When a current is supplied to one of the first and second driving coils **110** and **120** and the third driving coils **130***a* and **130***b* via the first and second printed circuit boards, the first and second magnets **211** and **231** and third magnets **241***a* and **241***b* that are spaced apart from the first and second **110** and **120** and the third driving coils **130***a* and **130***b* in a direction perpendicular to the optical axis are moved in a predetermined direction. When a current is supplied to the first driving coil **110**, the first magnet **211** is moved in the optical axis direction (z-axis direction). Also, when a current is supplied to the second driving coil **120**, the second magnet **231** is moved in the first direction (x-axis direction), and when a current is supplied to the third driving coils **130***a* and **130***b*, the third magnets **241***a* and **241***b* are moved in the second direction (y-axis direction). The current may be individually or simultaneously supplied to the first and second driving coils **110** and **120** and the third driving coils **130***a* and **130***b*.

While the first and second magnets **211** and **231** and the third magnets **241***a* and **241***b* are moved, the fixed frame **100** to which the first and second printed circuit boards **301** and **302** are electrically connected is fixed to the base **20** and is not moved, and thus, tension variation of the first and second printed circuit boards **301** and **302** is not caused while the moving frame **200** to which the first and second magnets **211** and **231** and the third magnets **241***a* and **241***b* are mounted is moved. Accordingly, the moving frame **200** may be accurately moved without being affected by the tension variation applied to the first and second printed circuit boards **301** and **302**.

In addition, by spacing the first and second **110** and **120** and the third driving coils **130***a* and **130***b* apart from the first and second magnets **211** and **231** and the third magnets **241***a* and **241***b* in a direction perpendicular to the optical axis, a thickness of the camera module in the optical axis direction may be reduced. In detail, even when the first and second magnets **211** and **231** and the third magnets **241***a* and **241***b* have larger thicknesses, the thickness of the camera module in the optical axis direction may not increase.

In the above-described embodiment, the first sub-moving frame **230** is moved in the first direction (x-axis direction), and the second sub-moving frame **240** is moved in the second direction (y-axis direction), but the embodiments are not limited thereto. For example, in contrast to the above-described embodiment, the first sub-moving frame **230** may be moved in the second direction (y-axis direction), and the second sub-moving frame **240** may be moved in the first direction (x-axis direction). Also, while a voice coil motor (VCM) method in which an electromagnetic force generated between a coil and a magnet is used to drive the moving frame **200** is used in the above-described embodiment, other methods for driving the moving frame **200**, for example, an ultrasonic wave motor method using a piezoelectric element or a method of driving the moving frame **200** by applying a current to a shape memory alloy may also be used.

According to the camera module of the above-described embodiments, a printed circuit board is connected to a fixed frame for three-axis driving, thereby providing an Auto Focus (AF) function and an Optical Image Stabilization (OIS) function whereby a lens may be precisely moved and a tension variation in the printed circuit board may be prevented or minimized.

For the purposes of promoting an understanding of the principles of the invention, reference has been made to the preferred embodiments illustrated in the drawings, and specific language has been used to describe these embodiments. However, no limitation of the scope of the invention is intended by this specific language, and the invention should be construed to encompass all embodiments that would normally occur to one of ordinary skill in the art.

The words "mechanism" and "element" are used broadly and are not limited to mechanical or physical embodiments, but can include software routines in conjunction with processors, etc.

The particular implementations shown and described herein are illustrative examples of the invention and are not intended to otherwise limit the scope of the invention in any way. For the sake of brevity, conventional electronics, control systems, software development and other functional aspects of the systems (and components of the individual operating components of the systems) may not be described in detail. Furthermore, the connecting lines, or connectors shown in the various figures presented are intended to represent exemplary functional relationships and/or physical or logical couplings between the various elements. It should be noted that many alternative or additional functional relationships, physical connections or logical connections may be present in a practical device. Moreover, no item or component is essential to the practice of the invention unless the element is specifically described as "essential" or "critical".

The use of the terms "a" and "an" and "the" and similar referents in the context of describing the invention (especially in the context of the following claims) are to be construed to cover both the singular and the plural. Furthermore, recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. Finally, the steps of all methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., "such as") provided herein, is intended merely to better illuminate the invention and does not pose a limitation on the scope of the invention unless otherwise claimed. Numerous modifications and adaptations will be readily apparent to those skilled in this art without departing from the spirit and scope of the present invention.

What is claimed is:

1. A camera module comprising:
- a lens barrel including at least one lens group;
- a moving frame that mounts the lens barrel and is movable in an optical axis direction, and in a first direction and a second direction that are perpendicular to the optical axis direction;
- a fixed frame that movably supports the moving frame and provides the moving frame with a driving force:
  - in the optical axis direction;
  - in the first direction; and
  - in the second direction,
  - wherein the fixed frame comprises a plurality of sidewalls that surround side portions of the moving frame;
- a printed circuit board disposed on a sidewall of the plurality of sidewalls, wherein the printed circuit board provides current to the fixed frame; and
- a base that fixes the fixed frame and comprises an image sensor that is spaced apart from the at least one lens group in the optical axis direction;
- wherein the fixed frame further comprises:
  - a first driving coil for moving the moving frame in the optical axis direction;
  - a second driving coil for moving the moving frame in the first direction; and
  - third driving coils for moving the moving frame in the second direction.

2. The camera module of claim **1**, wherein:
- the moving frame comprises first, second, and third magnets respectively corresponding to the first, second, and third driving coils.

3. The camera module of claim **2**, wherein the printed circuit board supplies a current to the first, second, and third driving coils to move the moving frame.

4. The camera module of claim **2**, wherein the first, second, and third driving coils are respectively spaced apart from the first, second, and third magnets in a direction perpendicular to the optical axis direction.

5. The camera module of claim **2**, wherein the first, second, and third driving coils are disposed in sidewalls of the fixed frame.

6. The camera module of claim **2**, wherein the fixed frame comprises a hole into which at least one of the first, second, and third driving coils is inserted.

7. The camera module of claim **2**, wherein the moving frame comprises a groove portion into which at least one of the first, second, and third magnets is inserted.

8. The camera module of claim **2**, wherein the moving frame comprises:

a first moving frame that is movably supported by the fixed frame in the optical axis direction; and

a second moving frame that is movably supported by the first moving frame in the first and second directions.

9. The camera module of claim **8**, wherein:

a plurality of ball bearings are disposed between the fixed frame and the first moving frame; and

a guide groove that guides the plurality of ball bearings in the optical axis direction is formed in at least one of the fixed frame and the first moving frame.

10. The camera module of claim **8**, wherein:

a plurality of ball bearings are disposed between the first moving frame and the second moving frame; and

a guide groove that guides the plurality of ball bearings in the first direction or the second direction is formed in at least one of the first moving frame and the second moving frame.

11. The camera module of claim **8**, wherein the second moving frame comprises:

a first sub-moving frame that is moved in the first direction, wherein the second magnet is disposed at a side of the first sub-moving frame; and

a second sub-moving frame that is moved in the second direction, wherein the third magnets are disposed at two sides of the second sub-moving frame.

12. The camera module of claim **11**, wherein:

the second sub-moving frame is movably supported by the first sub-moving frame in the second direction; and

the first sub-moving frame is movably supported by the first moving frame in the first direction.

13. The camera module of claim **12**, wherein:

a plurality of ball bearings are disposed between the first sub-moving frame and the second sub-moving frame; and

a guide groove that guides the plurality of ball bearings in the second axis direction is formed in at least one of the first sub-moving frame and the second sub-moving frame.

14. The camera module of claim **12**, wherein:

a plurality of ball bearings are disposed between the first sub-moving frame and the first moving frame; and

a guide groove that guides the plurality of ball bearings in the first direction is formed in at least one of the first sub-moving frame and the first moving frame.

15. The camera module of claim **12**, wherein the first sub-moving frame comprises a detour portion to make a detour with respect to the third magnets.

16. The camera module of claim **15**, wherein the detour portion and the third magnets are spaced apart from each other.

17. The camera module of claim **11**, wherein the first moving frame comprises a yoke that is disposed to correspond to the third magnets that prevents the second moving frame from detaching therefrom.

18. The camera module of claim **11**, wherein the fixed frame comprises first, second, and third sensors that correspond to the first, second, and third magnets, respectively.

19. The camera module of claim **18**, wherein the first, second, and third sensors are magnetic sensors.

20. The camera module of claim **19**, wherein the first sensor detects a position of the first magnet in the optical axis direction.

21. The camera module of claim **19**, wherein the second sensor detects a position of the second magnet in the first direction.

22. The camera module of claim **19**, wherein the third sensors detect a position of the third magnets in the second direction.

23. The camera module of claim **22**, wherein:

the third magnets are disposed at two sides in the first direction of the second moving frame; and

the third sensors are disposed at two sides in the first direction of the fixed frame.

24. The camera module of claim **23**, wherein a position of the moving frame in the second direction is detected based on:

a first detection signal detected by one of the third sensors; and

a second detection signal detected by other of the third sensors.

25. The camera module of claim **24**, wherein a position of the moving frame in the second direction is detected based on a third detection signal which is a sum of the first detection signal and the second detection signal.

26. The camera module of claim **23**, wherein a sum of a distance between one of the third sensors and one of the third magnets in the first direction and a distance between the other of the third sensors and the other of the third magnets is constant.

27. The camera module of claim **1**, wherein tension of the printed circuit board remains constant while the moving frame moves.

* * * * *